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DYNAMICS OF COMPOSITE MATERIALS AND ELASTIC STRUCTURAL ELEMENTS--ETC(U)
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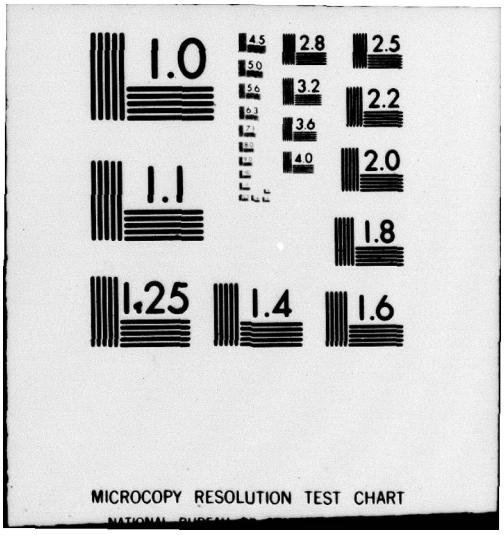
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The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Nonuniform rotor blade; Vibration characteristics; Composite plates; Bounds on eigenvalues.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

In this project effective methods have been sought for estimating bounds on eigenvalues and vibration characteristics of nonuniform rotor blades, composite plates, and other structural elements which consist of materials with nonuniformly varying properties.

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DYNAMICS OF COMPOSITE MATERIALS AND ELASTIC STRUCTURAL ELEMENTS WITH VARIABLE DIMENSIONS

FINAL REPORT

S. NEMAT-NASSER

September 1979

U. S. ARMY RESEARCH OFFICE

GRANT NO.: DAAG29-78-G-0149

NORTHWESTERN UNIVERSITY
Evanston, Illinois 60201

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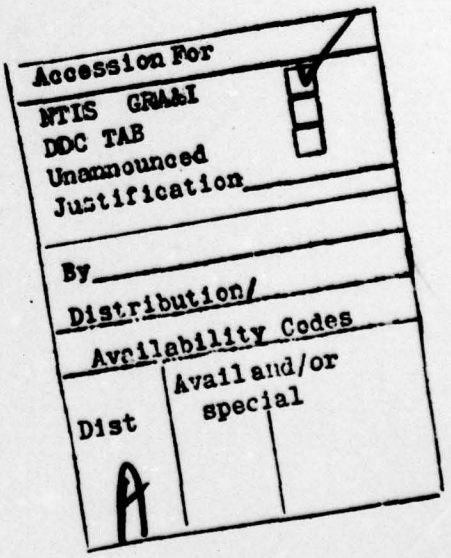

A. Statement of Problem Studied and Summary of Basic Results

In this project attention has been focused on developing effective methodologies for accurate calculation of the dynamic response of elastic composites, and vibration of elastic structural components with relatively large variations in their stiffness, mass distribution, and dimensions. The basic results obtained under this project are summarized in the following abstracts of the corresponding articles which have been completed at this writing.

1) Variational Methods for Eigenvalue Problems in Composites, by C. O. Horgan and S. Nemat-Nasser, Proceedings of the IUTAM Symposium on Variational Methods in the Mechanics of Solids, edited by S. Nemat-Nasser, Pergamon Press; to appear.

ABSTRACT: Eigenvalue problems with discontinuous coefficients occur naturally in many areas of composite material mechanics. In previous work, based on mixed variational schemes, an approximation technique of Rayleigh-Ritz type applied to a modified "new quotient" has been developed by Nemat-Nasser and coworkers and applied in estimating eigenvalues and eigenfunctions for such problems in a wide variety of contexts.

Alternative approaches, resulting from modification of classical Sturm-Liouville theory, have been established recently by the present authors. The central idea is to transform the one-dimensional Sturm-Liouville problems of concern to Liouville normal form. This leads to a problem with a single discontinuous coefficient which moreover occurs in an undifferentiated term. Eigenvalue estimates based on the transformed problem are established.

This paper provides a survey of these various methods for effective estimation of the eigenvalues of such problems. Related issues arising in the area of eigenvalue optimization are briefly discussed.

2) An Approach for Estimating Vibration Characteristics of Nonuniform Rotor Blades, by K.-W. Lang and S. Nemat-Nasser, AIAA Journal, in press.

ABSTRACT: A method is presented for determining the vibration characteristics of a rotating blade whose cross-sectional dimensions or mechanical properties may vary sharply or even discontinuously along its length. The coupled flapwise bending, chordwise bending, and torsional vibration of the blade is analyzed by the method of the new quotient which is based on

a variational statement proposed by Nemat-Nasser. In this approach, the nonuniform blade properties may be approximated by step (piecewise constant) functions. Two illustrative examples are given, and the results are compared with available experimental data and other numerical solutions. The comparison shows that the method of the new quotient yields very good results.

3) Finite-Element Analysis of Harmonic Waves in Layered and Fiber-Reinforced Composites, by S. Minagawa, S. Nemat-Nasser, and M. Yamada, International Journal for Numerical Methods in Engineering, submitted for publication.

ABSTRACT: The problem of harmonic waves in layered and fiber-reinforced composites is solved by a method of finite elements. Piece-wise linear approximating functions are used for the displacement and stress fields in a mixed variational formulation recently proposed by one of the writers in the form of a new quotient. To illustrate the accuracy and effectiveness of the method, approximate phase-velocities of harmonic waves in layered composites are computed, and compared with the exact solutions, where asymmetric and symmetric triangular meshes, and square meshes with interior nodes, are used. Calculations are also performed for harmonic waves in fiber-reinforced composites. Dispersion curves for these waves are obtained and displayed graphically.

B. Publications

C. O. Horgan and S. Nemat-Nasser, "Variational Methods for Eigenvalue Problems in Composites," Proceedings of the IUTAM Symposium on Variational Methods in the Mechanics of Solids, edited by S. Nemat-Nasser, Pergamon Press; to appear.

K.-W. Lang and S. Nemat-Nasser, "An Approach for Estimating Vibration Characteristics of Nonuniform Rotor Blades," AIAA Journal, in press.

S. Minagawa, S. Nemat-Nasser, and M. Yamada, "Finite-Element Analysis of Harmonic Waves in Layered and Fiber-Reinforced Composites," International Journal for Numerical Methods in Engineering, submitted for publication.

C. F. Philipponneau and S. Nemat-Nasser, "Vibration of Composite Circular Plates," in preparation.

C. Participating Scientific Personnel

Principal Investigator: Professor S. Nemat-Nasser

Visiting Scholars:

Professor C. O. Horgan (Michigan State University, East Lansing)

Professor S. Minagawa (Denkitsushin University, Tokyo, Japan)

Research Associate: Dr. K.-W. Lang (General Electric Company)

Graduate Students: Mr. James F. Dorris

Mr. Claude F. Philipponneau (no cost to grant)